Observations on the Family Coleophorides.—The Case.

By ALFRED SICH, F.E.S.

(*Continued from vol. xxxiv., p. 89.*)

One of the most essential conditions to lepidopterous larval life is that of moisture. Although certain larvae of the *Tineidae* and *Oecophoridae* are able to carry on their existence feeding on old hair, feathers, or other substances under exceedingly dry conditions, the majority of the Tineina need in their early stages a comparatively large amount of moisture. Another necessity to their successful life is the possession of means to escape the attention of other creatures that prey on them. The methods by which these two necessities are secured vary greatly. In the family under consideration and its allies, the *Lithocolletides* being very small insects are able to meet the difficulties by remaining between the cuticles of a leaf of their foodplant during the whole of their larval and pupal life. The *Gracilariides*, at least the larger species, pass their early larval life in a leaf and later, when the larva grows larger, either roll the leaf edge, or twist the apex of a leaf into a cone-shaped dwelling. The *Coleophorides* solve the problems by first living among flowers or seeds or in a mine in a leaf, and later forming a portable habitation, which may resemble other objects, but has not the appearance of a soft larva. Eventually this case is used as a convenient pupal habitation, but I believe it had no such origin. It was primarily a larval dwelling like the cones of the Gracilariids, which are not used as cocoons. Even now at least one species of *Coleophora*, *C. salicorniae*, is known to quit its case before pupation and *Goniodoma limoniella* does so likewise. The case may then be considered criginally as a habitation for the larva when it had become too large to hide in a calyx of its foodplant or between the cuticles of a leaf. As it is we may observe Coleophorid mines in *Holostea*, *Lotus*, *Ulmus* and *Corylus* from a distance, and if even the half grown larva were to live in the mine without a case, its mine would become so large as to be strikingly conspicuous. This is avoided by the larva dwelling in a case and making numerous small mines. The case is firstly constructed in order to retain the larva in a sufficiently moist condition, and secondly to protect it. Whatever the exterior of the case may present to view, the interior is always a hollow cylinder more or less closed at one end and lined with a substance apparently impervious to water. This may be silk applied as a fluid or it may be some special secretion. The result is that the case becomes very tough and opaque. After the larva has taken a meal in the wet interior of the leaf it retires into the case. Here even in a dry wind it is protected from undue loss of moisture and from too sudden change of conditions from a wet mine to a dry atmosphere or even hot sunshine. In those species which do not mine, the case surrounds them with a non-absorbant material, which prevents undue loss of their own moisture and also protects them against the inclemencies of the atmosphere. The same advantages are secured to all species while the larva is changing its skin, and more especially while undergoing the long winter sleep which may last from August till the end of the following April.

I will now describe in detail how some of the cases are constructed and enlarged. Each species has its own method and strictly adheres to it. It shows how strong is the instinct, inherited memory, or whatever we may call it, when we find a solitary larva forming its special case without instruction or example in exactly the same manner as did its parents, whom it has never even seen. Sometimes *C. caespititella*, *C. argentula* and probably other seed-feeders will, before making a case, form tubes or galleries of silk and vegetable atoms in the seed heads of their foodplants. These tubes, I imagine, enable the larvae easily to reach the seeds which are usually on the surface of the head, or when feeding to retire rapidly into the interior if danger threatens. Later in life these larvae make short portable tubes which they turn into cases. The case of *C. caespititiella* is typical of the Coleophorid. It is fairly cylindrical, its length about five times its diameter, it is somewhat flattened at the distal end where it is closed by three conical valves which meet at their apices. At the other end is the circular mouth strengthened by a slight lip or flange running outside. Above the mouth the case is slightly restricted. This species is fully grown in Autumn but *C. glaucicolella*, which forms a similar case, may be found feeding in Spring. *C. alticolella* uses the calyx of the rush as a foundation to its neat case, and *C. sylvaticella*, a fine species discovered by Dr. Wood, employs the calyx of *Luzula* for the same purpose. This species is one of those that take two years to reach maturity. When young it feeds on the seeds and after hibernation it commences eating the flowers in early summer. It passes the second winter as a full grown larva. Another of Dr. Wood's discoveries is the small *C. agrammella*, this makes a straight silken case with alternate light and dark longitudinal stripes. Its favourite food is *Juncus conglomeratus*, on which it feeds at the same time with other species. For this reason and from its small size it has been overlooked, but I have recorded it from Sussex and have found it in Surrey. The late Dr. Wood's fruitful *Study of our rush-feeding Coleophorae* has been recorded in a highly interesting manner (*E.M.M.*, 1892). I have examined the cases in which *C. laripennella* passes the winter to see which authorities were correct and found that it is really more or less covered with grains of sand, not with meal of the footplant only. The case of *C. virgaureae* is better hidden in the seed heads of *Solidago*, because the larva decorates it with some of the pappus. *C. artemisicolella* feeds on mugwort and *C. deauratella* living in flowers of clover, use parts of the flowers in forming their cases, but I have seen neither of them. I have found *C. frischella* on *Melilotus*; its case is formed of the shells of the seeds and has the appearance of a row of small beads. This species and others have been recorded as passing two years in the pupal state. It is not therefore wise to pin in the cabinet, without examination, those cases which do not yield the imago the first season.

Though I have found several cases of *C. albicosta* on furze bushes, its method of treating the calyx out of which its case is made, has escaped me. I confess that I have never seen any of the seed-feeders in the act of forming their cases, they live hidden away while young and are therefore difficult to observe minutely. When in their final cases they are more easily noticeable, indeed the rush feeders are quite conspicuous when their cases stand out from the seed-heads, and we then see how the larvae need the shelter of their cases for we sometimes find them where the rushes are growing in very bleak spots. The same may be said of *C. argentula* when feeding on the tops of yarrow plants in an open field. These are however the exceptions, for the Coleophorid is pre-eminently a lover of sheltered situations. As those plants that nourish the seed-feeders perfect their seeds in late summer and autumn and lose most of them before next spring, it is natural that the larvae should feed up quickly and hibernate fully grown. *C. ornatipennella*, only eating seed when young, hibernates in the third stadium; our *C. lixella* probably does the same. While on this question I may say that I have reason to believe that nearly all our British species and those inhabiting central and northern Europe hibernate either in the third instar or as fully grown larvae and that none pass the winter in the oval, pupal or imaginal state. Some of the seed-feeders have been observed to supplement their diet by eating the leaves of their foodplants as well as the seeds. Mr. H. J. Turner says that *C. artemisiella* will eat the leaves as well as the seeds and Baron Crombrugghe states that *C. artemisicolella* does so likewise (*Ann. Soc. Ent. Belg.*, 1907, p. 33).

We now have the leaf-miners to consider, and it is among them that we find the most interesting cases and here we can actually watch the progress of construction. There is no doubt that the form which some of the cases take is of cryptic value and does deceive casual enemies, but it is no protection against special parasites. There is one casual enemy against which the Coleophorid is protected by its case. This is the ant. In Britain ants are not so abundant, but in warmer parts of Europe, in north Italy and along the Mediterranean coast for instance, they are continually running over the leaves of trees and herbage. I have seen them running against Psychids crawling on tree trunks, these then promptly brought down the mouths of their cases on to the bark and the ants then took no further notice of them, though they sometimes run over the case. The Coleophorid when crawling must be protected in the same way. Insectivorous birds, especially titmice and the warblers, carnivorous beetles and Hemiptera, earwigs and a few solitary wasps are other casual enemies against which the case in its various forms is more or less protective. Any botanist, who has examined living plants under a good lens, must be aware of the numerous mites, thrips and minute immature forms of insect life, which haunt especially the flowers and the angles of the veins on the underside of the leaves. Mites, I am sure, destroy *Lithocolletis*, when by accident they are able to enter the mine, but I have seen them and other minute creatures worry unprotected larvae by running about them. The Coleophorid when in its case or mine is free from such unwelcome attention.

The dire enemies are the various species of internal parasites belonging to the Hymenoptera. These destroy great mumbers of Coleophorids. I have bred fairly large species, many smaller and numbers of minute ones. They all eat a round hole through the wall of the case on emergence. I have never seen any of these attack a larva; they may be able to pierce the case with their ovipositors. If they do this just after the larva has changed its skin, I imagine, they would meet with little resistance. The minute species may gain access to the case by squeezing themselves in between the valves at the apex. In 1919 I gathered a number of cases of *C. vibicella*, of which about ninety per cent. produced numbers of minute brillantly coloured Hymenoptera. In 1920, wishing one day to obtain living pupae, I gathered the first dozen cases I saw, ten *C. fuscedinella* and two *C. ibipennella*. On examination every one of these was found to contain parasites. These are instances of exceptionally severe attack. In some years very few parasites will be bred. These Hymenoptera are beautifully fashioned and, in contrast to many parasitic forms of life, show no loss of vital force. They appear to be gifted with as high an intelligence as any insect. I do not think I ever bred a dipterous parasite from a Coleophorid, but believe I have read of such an occurrence.

Before describing the actual methods of case-making I am tempted to say a very few words on silk. To the Coleophorid, and one may say to all Lepidoptera, silk is a necessity. Without silk they could make neither their larval nor pupal habitations which so many of them now find indispensible, and even those larvae which form no such dwellings, as certain *Satyridae* and *Lycaenidae*, which are said to pupate simply on the ground, need silk when changing their skins. Lepidopterous silk, like Arachnid silk, appears to vary in its properties. Sometimes it contracts on exposure to air, sometimes it shows no such contraction. It is highly interesting to watch a larva under a lens while it is forming its dwelling. A small *Gracilaria* larva has no bodily strength to roll the edge of a leaf. What it does first is to spin very rapidly a large number of silk threads parallel to each other along the extreme margin of the leaf and at right angles to it. In a very short time we see the margin folding inwards. This can only mean that the silken threads have contracted and drawn the edge of the leaf over. This also shows that the silk at each end of the threads has a very strong adhesive property. On the other hand when we watch a *Bucculatrix* building its beautiful cocoon we observe that it forms a series of arches which remain standing upright. When the first half of the cocoon has been made, the larva which until then had been lying outside, crawls under the arches and completes the second half of the cocoon over its body. Here there is no contraction of the silk or the arches would collapse. I believe Coleophorid silk has both properties, as the cuticles of the leaves, out of which many cases are formed, are very closely united; on the other hand the beautiful arches by means of which *C. palliatella* forms the scales that adorn its case appear to be made of incontractable silk, as well as the whole case and probably all the silken cases. One of our most common species is *C. lineolea*; its egg is laid on the upper surface of the leaf of *Ballota* or *Stachys* where these plants grow under the shelter of a hedge or even a wooden paling. On hatching, the larva eats its way through the base of the egg shell into the leaf, where it makes a minute mine, at this stage leaving its excrement in the mine. After a few days it changes its skin in the mine and then commences to form its first case. The mine consists of an oval space, out of which the larva has eaten the green cellular tissue, leaving only the upper and lower epidermis of the leaf entire. The larva now bites a slit in one of the cuticles and a corresponding slit in the other and then fastens the inner edges of both firmly together with silk. Then, if I remember rightly, it goes to the opposite side of the mine and repeats the process, but the slits here lie at an angle to those first made and very nearly meet them at one point. Now the larva severs the cuticles at this point, but does not fasten them together. The result is that a minute tongue-shaped sack is formed with its wide mouth still attached to the leaf. If we examine the leaves of the above mentioned plants in the middle of August, we may see these sacks partly cut free of the leaf. After the larva has taken a few meals in the mine it returns to the partly made case, and getting inside cuts it entirely free from the leaf and wanders away. Finally it fastens the case with silk to the underside of a leaf and commences a fresh mine. As the larva grows the case becomes too small, so it fastens the mouth end to the edge of a leaf and mines out the portion lying around as far as it can reach without leaving its case. It then cuts out and fastens together the two cuticles on each side of the mine, but leaving a small portion opposite the mouth of its case uncut. Finally this portion is cut and the larva crawls off with its case, which is now longer and wider. After a short time it lines the fresh part of the case with silk, or whatever the substance may be which renders the case tough and opaque. After making one or two similar further additions to the case and, I believe, again changing its skin, this time in the case, it crawls off the leaves and fastens its case to the stem of the foodplant near the ground, or to some adjacent stem of the hedge, or even to a wooden post, if there be one. Here it passes the winter and in March or April wakes up and mounts the new young stems of the plant and begins again to mine the leaves. It retains its old case and adds to it in the same way as before, but as the additions are larger the process may be watched without a lens. About the end of May or middle of June, the larva quits the leaves and again fastens its case up in similar situations as it did for hibernation. It then turns round in its case, so that its head is at the distal end, and pupates. In a few weeks the imago appears. I have seen this species living on plants completely covered with dust from the adjacent road, but by means of its case and mine it lives dust free. The case made from *Ballota* leaves carries the rough hairs of this plant, and is adorned along its sides by serrations of the leaf margin. When cut from the softer leaves of *Stachys sylvatica* the case has a more silky appearance. This simple method of case enlargement is adopted by several species. *C. viminetella* and *C. bicolorella* make the first portion of their cases in autumn. This becomes very dark during the winter, and when in spring pieces of fresh leaves are added the contrast is striking. Hence the name of the latter species. The same system, but with a modification, is employed when the larvae feed on long narrow leaves. When in spring *C. ornatipennella* has need to enlarge its case, which at this time somewhat resembles a grain of barley, it does not affix it by the mouth end, but fastens it lengthwise to a grass blade, so that the long edge of the case is in contact with the edge of the blade. It then mines out a long narrow space above the old case and overlapping it at either end. It cuts out the cuticles along the upper margin of this space and fastens them together, finally cutting the ends and thus freeing the new case from the leaf. The old case now lies along the back of the new one and stiffens it. The abundant *C. laricella* feeding on the long needles of larch, uses the same method. *C. potentillae* also lengthens its case in a simple manner. It makes many small mines, and when it leaves a mine it does not simply cut away its case from the silk moorings, as most species do, but cuts out a ring from the epidermis of the leaf lying immediately round the mouth of the case and walks off with the ring attached to the case. That is why the vacated mines of this species show such a large exit hole. In due time the case becomes elongated by a series of frills. This process is also partly used by *C. paripennella* and *C. fuscocuprella*. When the leaves of the foodplant are very small a method is adopted by means of which the whole leaf is added to the case. I have watched *C. saturatella* enlarging its case in this manner, when it was feeding on the common broom. The larva, case and all, mounts to the tip of a leaf and mines out the apical portion, it then splits the leaf down the centre and forces its case wedge-like into the gap where it is firmly fixed with silk. The portion of the leaf lying below the case is now mined out, and this basal part of the leaf now becomes the additional habitable portion of the case. Finally the leaf now incorporated in the case is severed from the plant. Another interesting species to watch is *C. albitarsella*. It may be found under hedges, usually on Ground Ivy, *Glechoma hederacea*, especially where this plant grows beneath a patch of stinging nettles. The finished case is long and slightly curved and at first sight it appears to be made entirely of black silk. I have seen the larva enlarging its case when the latter was about half its final size. It first spun the mouth of the case to the extreme margin of a *Glechoma* leaf and then mined out a comparatively small quadrate portion. After having cut and fastened together the cuticles on each side where the edges of the mine ran in continuation with the length of the case, it cut away the cuticles at the edge of the mine lying opposite the mouth, thus freeing the case from the leaf. In this way the case is lengthened. Later the larva lines the additional piece. So far the process has been that of *C. lineolea*, but as the larva grows it has to increase the bulk of its case. To do this it cuts open the case along the ventral portion and extends the edges with spinnings of silk along them to the required depth. At first this silk is white but later it becomes dark like the rest of the case. If we examine the long case when finished, we shall see that it consists of a silken sheath strengthened by leaf cuticle lying saddle-wise over the upper part. The cuticle is recognisable because it still carries the epidermal hairs of the plant. The initial case of this species is cut out of the lamina of the leaf and the whole process of lengthening and widening the case takes place several times during the larval life. Most of the above mentioned species are content with one case and, after the first change of skin in the mine, cut a case out of the lamina of the leaf, but *C. juncicolella*, when feeding on *Calluna*, eats out the whole interior of a leaf to form its first case. The subsequent changes of skin always take place within the case, and it is often after a change that the case is enlarged. I think the Coleophorid has five larval stadia. The only way to settle the point is to rear them from the egg and notice particularly when the larva ceases feeding for a day or two. This usually means a moult and after the larva has moved its case again I have sometimes found the old head and skin on the spot where the case rested.

We now come to those species whose habit it is to make more than one case during their larval life. *C. fuscedinella* is a species easily obtainable on birch which is a good food to rear it on. The larva after changing its first skin in its first mine cuts out a minute case. Its method is more simple and quicker than the leisurely one of *C. lineolea*. It slits the upper and lower cuticles of the mine in a curved line and spins the inner edges of the cuticles together. It repeats the process on the other side of the mine. At this stage the larva lies between the joined cuticles which are already cut free of the mine, except at the extremities of the curved lines. Lastly the larva cuts the case free and walks off, very soon spinning it to the underside of a leaf in order to take a meal. I believe this method is adopted by most of the Coleophorid leaf-miners when forming their initial cases. This minute case soon becomes too small, so the larva has to enlarge it and it is interesting to find that it adopts the same system as that described when mentioning *C. potentillae*, namely by adding rings to the mouth, but it is not content with this process alone. It also cuts open the case along the venter and extends the severed margins with silk and reunites them, as described above when treating of *C. albitarsella*. The use of these methods of case enlargement by species belonging to three separate groups points to a community of descent, however widely the species may now be separated. After some weeks the case becomes so enlarged that the original one, cut out of the leaf, simply appears as a black patch on the back of it. With the case in this condition the larva passes the winter usually attached to a twig just above a leaf bud. When in early spring the larva begins to feed again and grows, it continues to enlarge its case in the same manner and in a few weeks the old almost black winter case contrasts strongly with the pale additions of the spring. When the leaves of the foodplant have grown sufficiently firm, the larva, differing from all those previously described, makes an entirely new case. It spins its old case to the base of a leaf close to the margin and eats out the cellular tissue in a straight line along the margin of the leaf, forming a space about twice the length and double the width of its own body. To do this it must of course come quite outside its old case, which it now abandons for good. When this mine is finished, the larva cuts slits in both cuticles along the edge of the mine lying nearest the mid rib of the leaf from base to apex. It then spins the two severed cuticles firmly together. The new case is now a sheath composed of two walls and is still attached to the leaf at the base and apex. The larva is inside this and now it mounts to the apex and severs the two cuticles there but does not unite them. It then returns to the base of the case and treats that in the same manner, clinging to the leaf with its thoracic legs as it finally cuts the case free from the leaf. It then crawls away. After a day or two it completes the case by rounding the mouth, forming three valves at the apex and by lining the interior. The case now resembles in shape that described for *C. caespititiella* but otherwise it is totally different. The leaf from which the case has been made now shows a comparatively large piece missing from the margin and the little abandoned case fastened near the base. In May we can often find leaves so treated on birch, elm and alder. Similarly treated leaves on oak will show the work of *C. lutipennella* and those on hawthorn that of *C. nigricella*, or more rarely that of *C. hemerobiella*, the last may be recognised by the very long curved tube of the abandoned case. A few species are not content with two cases but certainly form three and I believe the closely allied species, *C. gryphipennella* and *C. siccifolia*, make four cases. I have had eggs and first cases of the former but have not carried it through its life cycle. It hibernates as a young larva. I know that *C. siccifolia* makes three cases, but the smallest cases, I have found, appear to be too large to be the initial cases, so I believe it must make four cases. The last case in which it hibernates fully grown is well known. It is the usual cylinder but with a very large piece of leaf curling over it. On this account it has been described by the libellous name of the "clumsy tailor"; I consider it as one of the cleverest cases. If we examine a whitethorn hedge in winter or early spring we shall see many old shrivelled leaves still adhering to the twigs, not in their natural positions, but caught in the forks of the twigs in the interior of the hedge. If *C. siccifolia* is an inhabitant of the hedge, some of these apparently merely shrivelled leaves will contain the well hidden hibernating larva.

C. limosipennella is a third species which certainly makes three cases. This and *C. badiipennella*, instead of forming three valves at the apical ends of their cases, are content with two only and the same may be said of most of the species which spin their cases entirely of silk.

C. limosipennella cuts its cases out of the leaf margin just as *C. fuscedinella* does its final case and *C. badiipennella* makes its final case also in the same way. This method is nearly the most rapid and labour saving as only one side of the case requires fastening together. *C. salicorniae* is said to form its case of a hollowed stem of its foodplant which may require even less labour. The most independent way of forming a case is that adopted by those species which build the so-called pistol cases. In 1920 I was lucky enough to obtain eggs from a captured ♀ of *C. ibipennella*, Stt. (non Zeller). These were laid on the leaves of birch and I was able to watch how the larvae commenced to form their cases. The method employed is utterly different from any of the foregoing. The larva begins to mine in the usual manner, and after a day or two cuts a round hole out of the lower cuticle of the mine. Over this hole it forms a dome-shaped structure of its own silk mixed with the debris from the hole and with its own black excrement. From time to time it adds silk and excrement to the dome which in a day or so takes the appearance of a microscopical thimble thickly covered with black dots. The larva now gets inside the thimble, cuts it free of the leaf and crawls off to make a fresh mine. To enlarge and perfect its case, it now uses silk only and by frequent spinnings it finally forms a miniature black pistol case. In this it hibernates and in spring, as the larva grows, it lengthens its case by spinning at the mouth and widens it, I believe, by cutting it down the venter and extending the margin. These operations appear always to take place during the dark. These black pistol cases are conspicuous, but when resting on the leaves of trees they may be mistaken for birds' droppings, or when on low herbage the long cases may be passed over as leguminous pods, which are often black when the seeds are ripe. The most remarkable of them is that of *C. palliatella*. The posterior portion of this case is almost enveloped in a mass of beautiful fan-shaped scales all elaborately spun of silk. After hibernation these pistol case makers show a freedom of habit. That is they are not all tied down to the mining habit. Stainton's *C. ibipennella* and *C. anatipennella* will eat the whole of the upper surface of a leaf making a kind of lattice work between the veins, while the latter species may be found on the top of a shoot of blackthorn eating the young leaves entirely as a Noctuid larva would do. Another species, which I believe is still undescribed, is fond of making its spring meals off the male catkins of birch. The larvae of Coleophorids do not thrive in closed boxes as so many micro-larvae do, they require plenty of air. I use Stainton's method. Sprays of the foodplant are placed in a bottle with water which is plugged with cotton wool and the whole surrounded by a glass cylinder covered with gauze at the top. Care must be taken that the plant does not touch the cage otherwise the larva will crawl to the top and wander aimlessly. It then has to be replaced on the plant. If the case is held between the thumb and finger the larva will come partly out, it should then be held to the plant till it has taken hold. This operation requires a little patience because the Coleophorid, like many small larvae, nearly always spins a ladder of silk in its progress. Burdened by its case it requires a firm foothold which the ladder provides, and one has to wait till the first two or three rungs have been spun. The best opportunity for studying the habits of this family is afforded, when we find the species in the garden or in some handy place where we may observe them frequently in their natural habitat without disturbing them. In these observations on the cases I have endeavoured to show that each species has its own particular method of forming its case or cases, and that the members of a group of species usually form their cases on the same principle. Each larva has in it the inherited architectural instinct peculiar to its species. The case is the expression of this instinct and I maintain that by the study of the cases and especially of the methods employed in the actual building of them, we gain an insight, not only into the descent of species, but also into the lines of that descent. Though it would be absurd to attempt to classify the genus by the cases alone, I feel sure, that in working out the inner phylogeny of the genus the cases must be taken into consideration. I feel convinced that, for example, a species like *C. lineolea*, which forms its case of vegetable matter could never have arisen from a species like *C. anatipennella*, which spins a case entirely of silk. On the other hand we may get an idea as to how the black silk pistol case arose from the vegetable case. Let us take *C. albitarsella*, which is intermediate between the two extremes; it lengthens its case just as *C. lineolea* does, but it increases the depth of its case exactly as *C. anatipennella*. In this case the vegetable portion is even now of small account, and we can conceive that in time the larva might neglect this, and spin its case entirely of silk.

(*To be continued.*)

Preliminary Observations on the British Vanessids.

By HAROLD B. WILLIAMS, LL.B., F.E.S.

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(*Continued from page 95.*)

1. Progressive variation of *Aglais urticae*.

There are a number of features in the variation of *A. urticae* in which a transition in the direction of the markings of *V. io* is observable. Foremost among these I may mention the obsolescence of the "puncta" in many forms (*ichnusoides*, Selys, etc.) and the obsolescence of the "nota" in others. I have, apart from extreme forms, an example without trace of "puncta," and one with only faint traces of the "nota," both specimens otherwise normal. I believe Mr.